APPENDIX 6-3

HYDRAULIC MODEL
TASK 5.3.3.7.2 - HYDRAULIC MODEL DOCUMENTATION MEMORANDUM

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BLACK & VEATCH

TECHNICAL MEMORANDUM

South Florida Water Management District
EAA Reservoir A-1
Work Order No. 5

B&V Project 141522
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Task 5.3.3.7.2 Hydraulic Model Documentation Memorandum
Hydraulic Model

To: Distribution

From: Frank Means, Klint Reedy

1. OBJECTIVE

All HEC-RAS models and calculations are in NGVD29, both input and output results. To convert to NAVD88 subtract 1.4 ft from NGVD29, (NGVD29-1.4 ft=NAVD88). Conversion to NAVD88 has been completed for the text in the BODR. Calculations and model runs are in NGVD29 and text in the BODR is in NAVD88 unless otherwise stated.

The purpose of this technical memorandum is to document the open channel hydraulics modeling software and input/output files used for the EAA Reservoir A-1 hydraulics evaluation. This Hydraulic Model Documentation Memorandum provides a description of the modeling tools utilized to perform the evaluation and summarizes the key assumptions made when modeling.

2. MODEL DESCRIPTION AND APPLICABILITY

The U.S. Army Corps of Engineers Hydrologic Engineering Center River Analysis System (HEC-RAS 3.1.3 May 2005) computer model was used to analyze the hydraulic characteristics of the NNR canal. An existing HEC-RAS model was previously compiled and was provided by the District on a CD-ROM included with the "*Bolles & Cross Canals Preliminary-Hydraulics Report."* The specific HEC-RAS model that was used for the analysis described herein was, *"existing.prj*," which contained reaches for the Miami River, North New River, Bolles canal, and the Cross canal. A plan view of the provided model layout is illustrated Figure 1.

In order to focus on the ability of the NNR canal to convey water to and from Reservoir A-1, the model of the regional canals was dissected to only include the NNR canal. The model used for this analysis begins at Lake Okeechobee and extends south to structure S-7. The connections to the STA 3/4 Supply canal, Bolles and Cross canals were removed to be consistent with the portions of the system presented on Figures 2 and 3. A profile of the NNR canal is shown on Figure 4.

Various model configurations were developed from the original model. The upstream end of the model is River Station 30 (RS 30). The Bolles and Cross canal intersection is located at approximately RS 24. The proposed Northeast pump station is located at approximately RS 16. G-370 pump station is located at RS 8. Models were constructed to determine the capacity in the NNR canal with flow traveling north to south, from Lake Okeechobee to G-370 pump station. Models were also constructed with flow traveling south to north beginning at G-370 flowing to the Bolles and Cross connection.

3. MODELING INPUT AND ASSUMPTIONS

The open channel modeling was performed using the steady state option within HEC-RAS. The mixed flow regime mode was utilized in the modeling. To operate with a mixed flow regime, upstream and downstream boundary conditions are typically required to be defined within the model. However, due to the flat slope (i.e. lack of relief) of the NNR canal all flows are in the subcritical flow regime and therefore upstream boundary conditions for the modeling scenarios were not required. Although not required, the upstream boundary conditions were set at critical depths to allow HEC-RAS to operate in the mixed flow regime mode.

3.1 Assumed Inflow and Outflow Conditions

The steady flow model is used to simulate all the inflows and outflows to and from the NNR canal. Inflows are assumed to be flows conveyed downstream from Lake Okeechobee to the Bolles/Cross intersection or lateral inflows representing farm pump discharges into the NNR canal between the Bolles/Cross intersection and the G-370 pump station.

As shown on Figure 2, RS 16 is located just south of the future Northeast pump station. When in operation, the Northeast pump station will extract water from the NNR canal and transfer towards Reservoir A-1. Therefore, when simulating the Northeast pump station operation, the flow in the NNR canal is reduced by the simulated flow rate of the Northeast pump station and the resulting flow at RS 16 is the flow that bypasses the Northeast pump station and remains in the NNR Canal. At RS 15 and RS 11 there are more lateral inflow points. After RS 11, the total remaining flow in the NNR canal is conveyed downstream to the G-370 pump station, where it is assumed that all remaining flows are pump out of the NNR canal and into the A-1 Reservoir.

3.2 Modeling NNR Flowing North to South under Dry Conditions

For the dry weather condition all flows were assumed to come from Lake Okeechobee and be pumped to the Bolles/Cross canal intersection via the regional canal system. For the configuration where the flow is conveyed north to south, the downstream boundary conditions were dependent upon the Water Surface Elevation (WSE) required to operate the G-370 pump station. For these modeling analyses the WSE on the suction side of the G-370 pump station were set at 8.6 ft, 7.6 ft, and 6.6 ft NAVD.

3.3 Modeling NNR Flowing South to North under Dry Conditions

For the configuration where the flow is conveyed south to north, a downstream boundary condition was established at the Bolles and Cross connection. At this point the downstream boundary conditions were varied from 8.6 ft to 10.6 ft NAVD.

3.4 Modeling NNR Flowing North to South under Wet Conditions

During wet weather conditions, water will collect in the agricultural areas and the farmers must pump the rain water off the farm lands and into the adjacent canals. These wet weather lateral inflows were estimated from modeling results performed by A. D. A. Engineering, Inc utilizing a 2 x 2 simulation model of the entire EAA area. For this analysis, A.D.A provided estimated lateral inflow values assuming ¾ inches of runoff per day and 1-1/2 inches of runoff per day. Table 1 summarizes the estimated lateral inflow for each assumed runoff event and the location along the canal where the flow is anticipated to be introduced to the NNR canal.

3.5 Modeling the Northeast Pump Station Operating Range

Various scenarios were modeled to develop tables and curves for assisting in the design of the Northeast pump station. These scenarios included transferring water into Reservoir A-1 under a large range of wet weather conditions and dry weather conditions. These scenarios also considered how a large range of potential G-370 pump station operating conditions could impact the Northeast pump station.

The analysis evaluated utilizing the Northeast pump station to transfer flow out of Reservoir A-1. This condition is assumed to occur during the dry season when water stored in Reservoir A-1 is utilized to meet water demands. Because south to north flows are only assumed to occur during the dry season, no lateral inflows are assumed. Also the G-370 pump station is not operating under this scenario.

3.6 Modeling Verification

In addition to making modifications to the existing model to incorporate and evaluate the proposed new facilities, Black & Veatch utilized other hydraulic modeling tools to confirm the HEC-RAS modeling was simulating realistic conditions. Specifically, spreadsheets and hand calculations were performed to double check the HEC-RAS results.

Also to verify that the model was calculating the expected water surface elevations, A.D.A. Engineering, Inc assisted with confirmation that the settings for anticipated lateral inflows during ¾" and 1.5" runoff events were appropriate.

4. HYDRAULIC MODELS

As stated above, the HEC-RAS "existing.prj" model was provided as part of a previously prepared report. From this model several other models were developed. To perform a simulation in HEC-RAS, four model components are required. 1.) Project File *.prj 2.) Plan File *.p01 3.) Geometry File *.g01 and 4.) Flow File *.f01. Utilizing an array of model component files, several NNR canal operating conditions were simulated.

The Black & Veatch, *Task 5.3.3.6.2 Hydraulic Model Summary Technical Memorandum,* dated 11 July 2005, presents Tables 1 through 7 which include the results from 21 select model runs. These seven tables help describe the hydraulic characteristics of the NNR canal by analyzing the capacity of the existing channel considering velocity restrictions, free board restrictions, and

target water surface elevations. Simulations were also performed to evaluate the sensitivity to operating the NNR canal without velocity restrictions and with improvements made to the canal such as removing the high point (hump) downstream of the Bolles/Cross intersection.

As part of the final version of this memorandum, the model input and output files for the 21 runs will be provided in Appendix 6.10 – HEC-RAS Model Files. In Appendix 6.10, a list of file combinations used for each of the 21 runs is also included so that the simulations can easily be repeated if desired. Detailed explanations of the hydraulic modeling results are provided in the *Task 5.3.3.6.2 Memorandum.*

5. HEC-RAS MODEL FILES

For the final model documentation memorandum, Appendix 6.10 will include the HEC-RAS model files, including the following files, which were developed during the modeling evaluation.

- Project File – EAA_Exist_BV.prj
- Plan Files – EAA_Exist_BV.p.01 through EAA_Exist_BV.p.68
- Geometry Files - EAA_Exist_BV.g.01 through EAA_Exist_BV.g.16
- Flow Files - EAA_Exist_BV.f.01 through EAA_Exist_BV.f.67

Of this long list of files, the following were the files used to develop the results from the 21 runs summarized in the 7 tables presented in the *Task 5.3.3.6.2 Hydraulic Model Summary Technical Memorandum,* dated 11 July 2005.

5.1 NNR Flowing South with no Lateral Flows

5.1.1 Model Input Files

- *Project file - EAA_Exist_BV.prj*
- *Plan File - EAA_Exist_BV.p60*
- *Geometry File - EAA_Exist_BV.g07*
- *Flow File - EAA_Exist_BV.f60*

5.1.2 Model Output as Summarized in Table 1 from Task 5.3.3.6.2 Memorandum

- Model Output Profile 1 = Table 1 / Run 1 Data = 525 cfs
- Model Output Profile 4 = Table 1 / Run 2 Data = 1260 cfs
- Model Output Profile 7 = Table 1 / Run 3 Data = 2025 cfs

5.2 NNR Flowing South with Lateral Flows Due to ¾-inch Rain

5.2.1 Model Input Files

- Project file - EAA_Exist_BV.prj

- Plan File - EAA_Exist_BV.p59
- Geometry File - EAA_Exist_BV.g07
- Flow File - EAA_Exist_BV.f59

5.2.2 Model Output as Summarized in Table 2 from Task 5.3.3.6.2 Memorandum

- Model Output Profile 1 = Table 2 / Run 1 Data = 1575 cfs
- Model Output Profile 4 = Table 2 / Run 2 Data = 1961 cfs
- Model Output Profile 7 = Table 2 / Run 3 Data = 2736 cfs

5.3 NNR Flowing South with Lateral Flows Due to 1 1/2-inch Rain

5.3.1 Model Input Files

- *Project file* - EAA_Exist_BV.prj
- *Plan File* - EAA_Exist_BV.p61
- *Geometry File* - EAA_Exist_BV.g07
- *Flow File* - EAA_Exist_BV.f61

5.3.2 Model Output as Summarized in Table 3 from Task 5.3.3.6.2 Memorandum

- Model Output Profile 1 = Table 3 / Run 1 Data = 2272 cfs
- Model Output Profile 4 = Table 3 / Run 2 Data = 2682 cfs
- Model Output Profile 7 = Table 3 / Run 3 Data = 2971 cfs

5.4 NNR Flowing North with no Lateral Flows

5.4.1 Model Input Files

- *Project file* - EAA_Exist_BV.prj
- *Plan File* - EAA_Exist_BV.p68
- *Geometry File* - EAA_Exist_BV.g06
- *Flow File* - EAA_Exist_BV.f67

5.4.2 Model Output as Summarized in Table 4 from Task 5.3.3.6.2 Memorandum

- Model Output Profile 1 = Table 4 / Run 1 Data = 1225 cfs
- Model Output Profile 4 = Table 4 / Run 2 Data = 2510 cfs

- Model Output Profile 7 = Table 4 / Run 3 Data = 2890 cfs

5.5 NNR Flowing South without Hump no Lateral Flows

5.5.1 Model Input Files

- *Project file* - EAA_Exist_BV.prj
- *Plan File* - EAA_Exist_BV.p65
- *Geometry File* - EAA_Exist_BV.g12
- *Flow File* - EAA_Exist_BV.f64

5.5.2 Model Output as Summarized in Table 5 from Task 5.3.3.6.2 Memorandum

- Model Output Profile 1 = Table 5 / Run 1 Data = 720 cfs
- Model Output Profile 2 = Table 5 / Run 2 Data = 830 cfs
- Model Output Profile 3 = Table 5 / Run 3 Data = 800 cfs

5.6 NNR Flowing North without Hump no Lateral Flows

5.6.1 Model Input Files

- *Project file* - EAA_Exist_BV.prj
- *Plan File* - EAA_Exist_BV.p64
- *Geometry File* - EAA_Exist_BV.g16
- *Flow File* - EAA_Exist_BV.f63

5.6.2 Model Output as Summarized in Table 6 from Task 5.3.3.6.2 Memorandum

- Model Output Profile 1 = Table 6 / Run 1 Data = 1310 cfs
- Model Output Profile 2 = Table 6 / Run 2 Data = 2700 cfs
- Model Output Profile 3 = Table 6 / Run 3 Data = 3200 cfs

5.7 NNR Flowing South without Velocity Restrictions

5.7.1 Model Input Files

- *Project file* - EAA_Exist_BV.prj
- *Plan File* - EAA_Exist_BV.p52
- *Geometry File* - EAA_Exist_BV.g07
- *Flow File* - EAA_Exist_BV.f54

5.7.2 Model Output as Summarized in Table 7 from Task 5.3.3.6.2 Memorandum

- Model Output Profile 4 = Table 7 / Run 1 Data = 1375 cfs

5.7.3 Model Input Files

- *Project file* - EAA_Exist_BV.prj
- *Plan File* - EAA_Exist_BV.p54
- *Geometry File* - EAA_Exist_BV.g12
- *Flow File* - EAA_Exist_BV.f53

5.7.4 Model Output as Summarized in Table 7 from Task 5.3.3.6.2 Memorandum

- Model Output Profile 2 = Table 7 / Run 2 Data = 4200 cfs
- Model Output Profile 1 = Table 7 / Run 3 Data = 1900 cfs

6. REFERENCES

Jacobs/MWH, Bolles & Cross Canals Preliminary-Hydraulics Report June 15, 2004

A.D.A Engineering 1800 Old Okeechobee Road, Suite 102, West Palm Beach, FL 33409

U.S. Army Corps of Engineers Hydrologic Engineering Center River Analysis System (HEC-RAS 3.1.3) May 2005 computer model

TABLES

Table 1 Lateral Inflows to NNR

River Station	3/4" Runoff Lateral Inflow (cfs)	1.5" Runoff Lateral Inflow (cfs)
RS 23	309	618
RS 22	71	142
RS 21	130	260
RS 20	30	60
RS 19	145	290
RS 18	164	328
RS 17	167	334
RS 15	580	1160
RS 11	165	330

FIGURES

Figure 1 HEC-RAS Model the EAA System

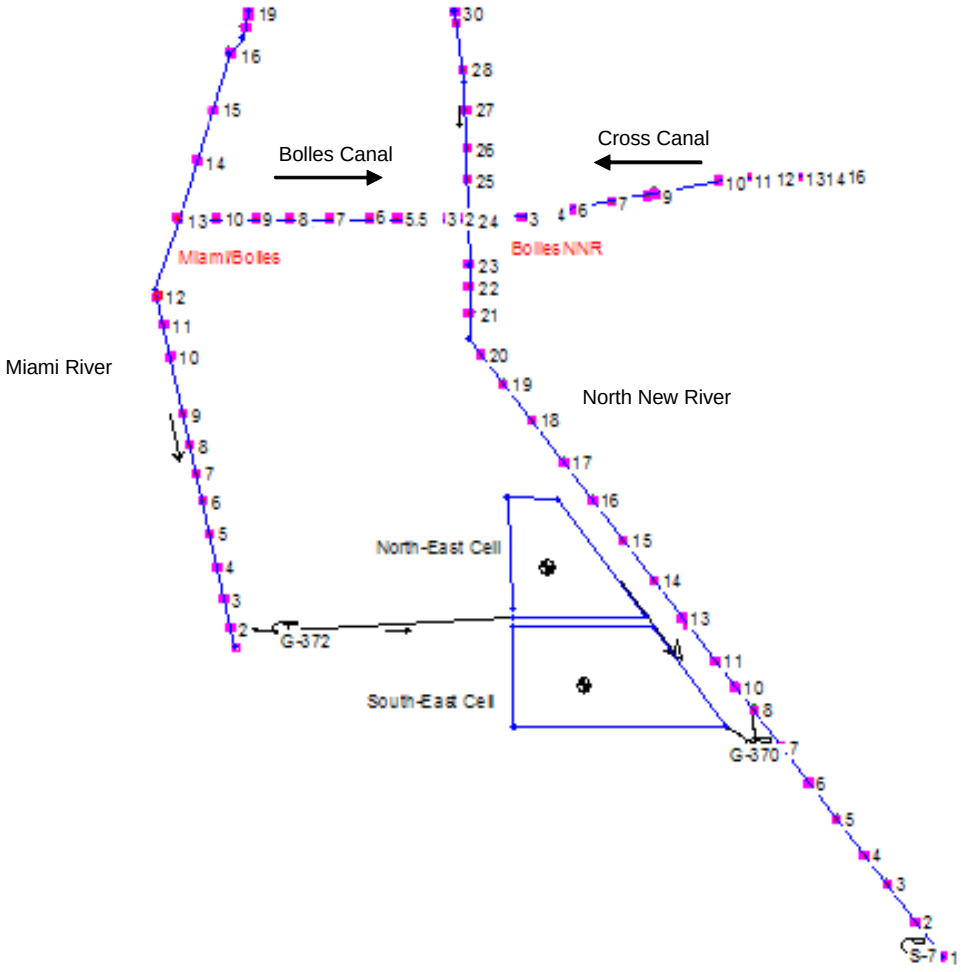


Figure 2 NNR Flowing South – Dry Conditions

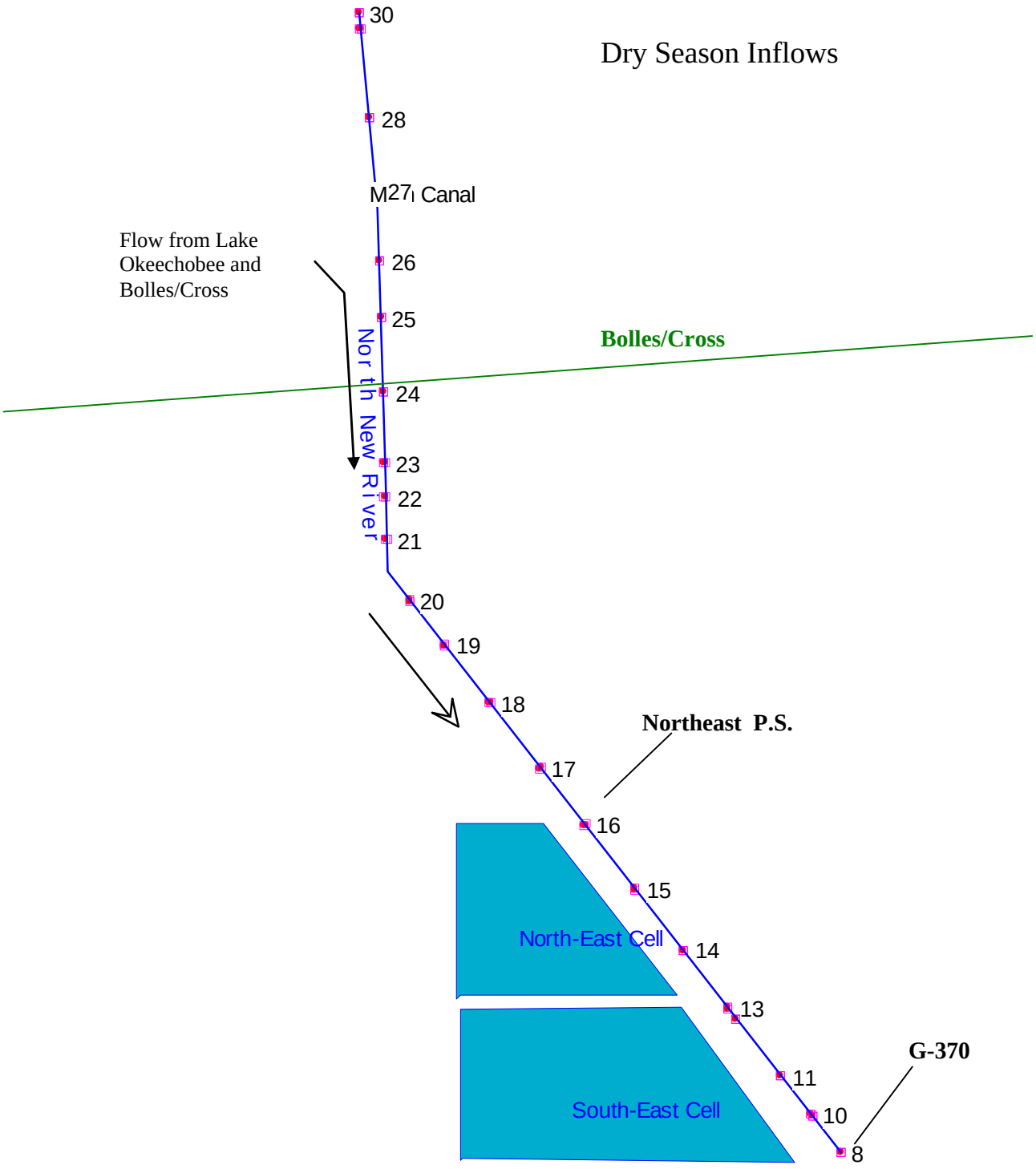


Figure 3 NNR Flowing South – Wet Conditions (3/4-inch Wet Season)

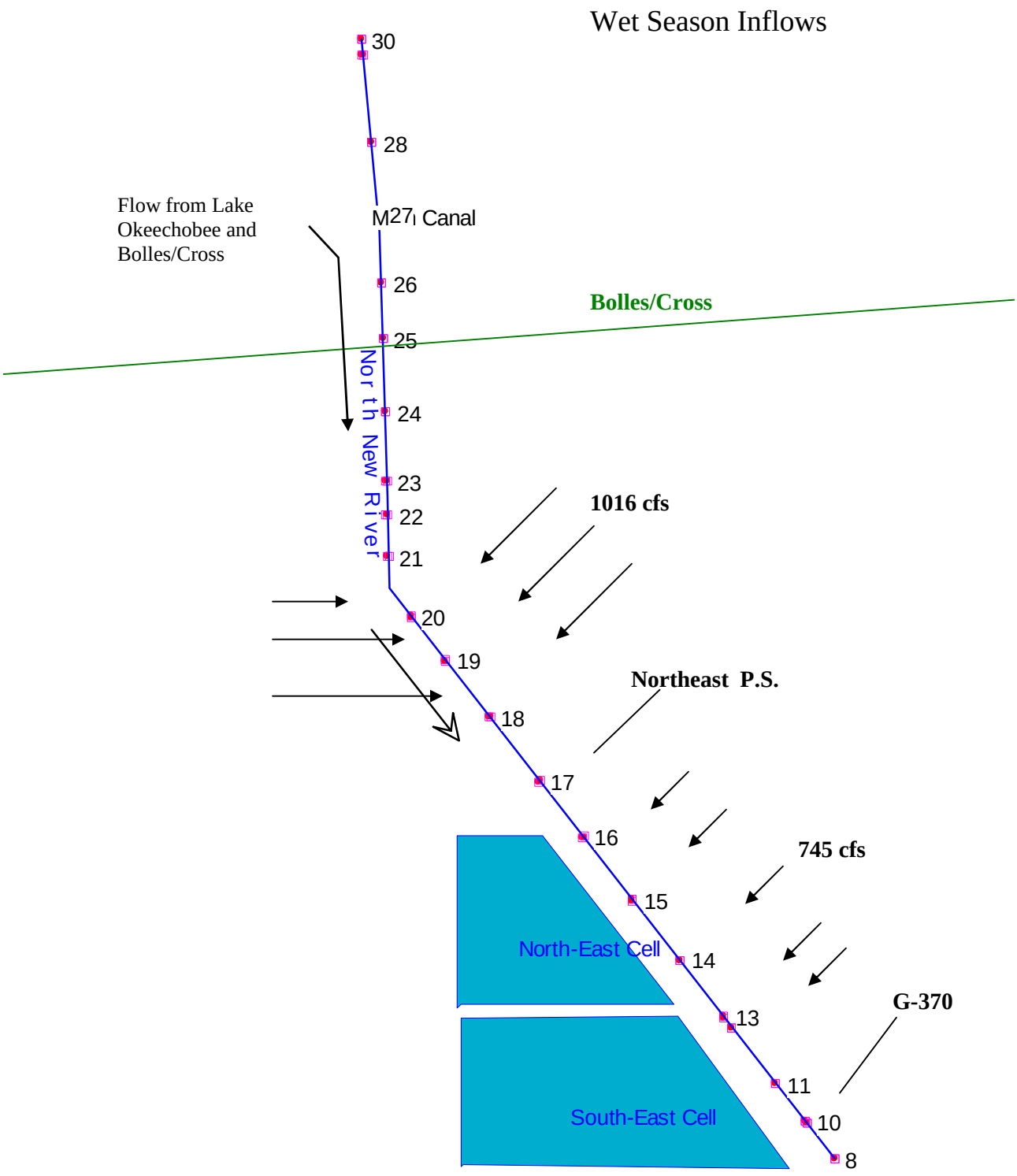
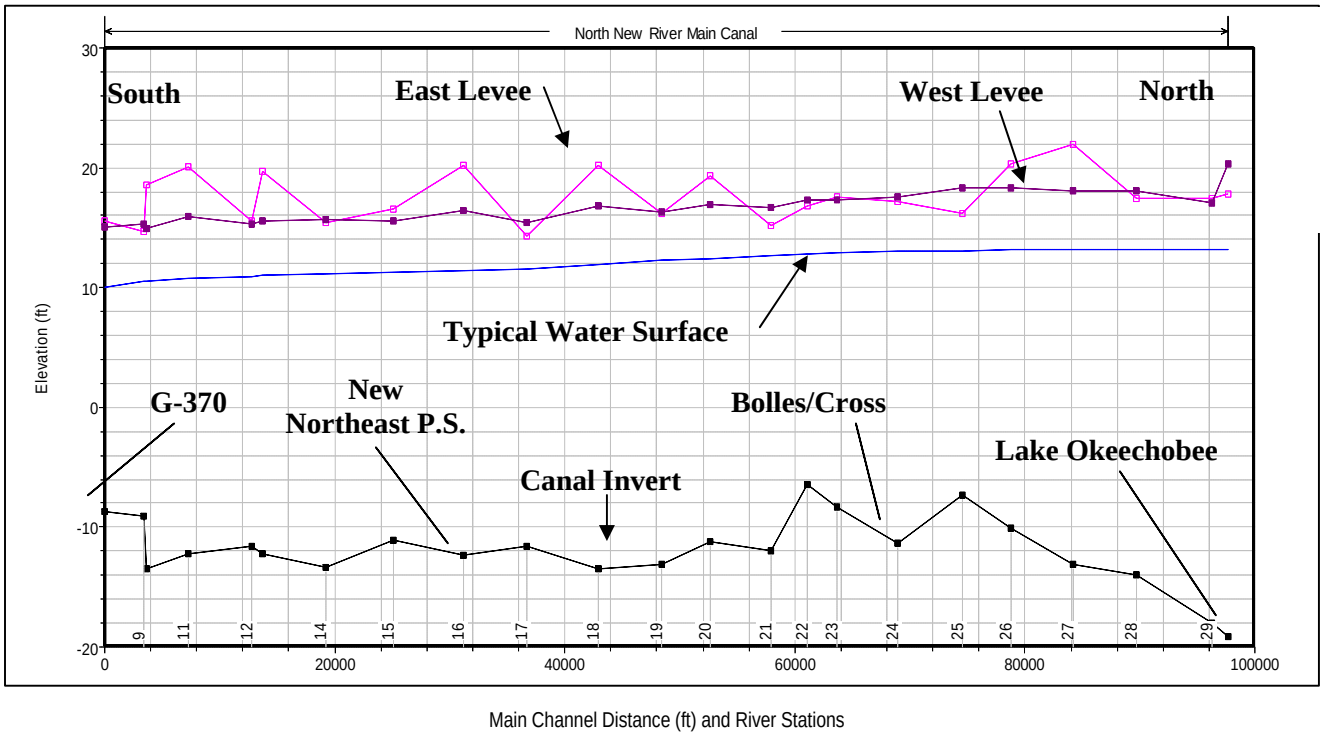


Figure 4 NNR Canal Profile



Elevation (ft) is NGVD 29
NGVD 29 – 1.4 ft. = NAVD88